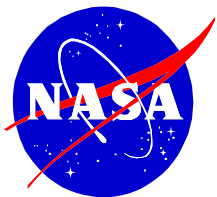


Gamma-Ray Large Area Space Telescope (GLAST)

Science Instrument - Spacecraft Interface Requirements Document DRAFT Version 0.4a

July 14, 2000



Revision History

Version	Description	Date
0.1	Initial draft released with draft AO.	1/26/99
0.2	Revised per comments to draft AO.	4/14/99
0.3	Updated section 2, and paragraphs 3.2.2.7.2, 3.2.3.1, 3.2.3.2.2, 3.2.4.7, and 3.2.5.2.7 for AO release.	8/3/99
0.4	Revised per selected instrument and inputs from instrument team and spacecraft team	4/7/00

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List of Acronyms

ACS	Attitude Control Subsystem
bps	bits per second
C	Centigrade
CDHS	Command and Data Handling Subsystem
CG	Center of Gravity
Dec	Declination
g	gravity
GRB	Gamma-Ray Burst
GSFC	Goddard Space Flight Center
Hz	Hertz
IDEAS	Interactive Design Engineering Analysis System
IR	Infrared
K	Kelvin
k	kilo
kg	kilogram
K	Kelvin
LET	Linear Energy Transfer
m	meter
mm	millimeter
M	Mega
MECO	Main Engine Cut Off
Mil Std	Military Standard
PPS	Pulse Per Second
RA	Right Ascension
RSS	Root Sum Squared
RT	Remote Terminal
SC	Spacecraft
SEIT	System Engineering, Integration and Test
SI	Science Instrument
SINDA	System Improved Numerical Differencing Analyzer
sr	Steradian
SSR	Solid State Recorder
TBR	To Be Resolved
TBD	To Be Determined
TDRS	Tracking and Data Relay System
TRASYS	Thermal Radiation Analysis System
TSS	Thermal Synthesizer System
UTC	Universal Coordinated Time
V	Volt
W	Watt

1 Introduction

1.1 Purpose

The primary purpose of this Interface Requirements Document (IRD) is to describe and specify the interfaces between the primary science instrument and the spacecraft. However, it also provides the launch vehicle constraints on these system elements, provides design guidelines in certain areas, and includes environmental estimates for radiation and micrometeoroids. In addition, it assigns certain interface responsibilities.

The current version of this document is the means by which instrument accommodation requirements are communicated to a number of spacecraft study contractors. At the same time it serves to identify the interface standards to which the instrument is designed and to obtain confirmation of them from the spacecraft study contractors.

1.2 Relation to Other Documents

The requirements in this document normally flow down directly to instrument and spacecraft systems from either the Science Requirements Document or the Mission System Specification. In addition, either the Instrument Performance Specification or the Spacecraft Specification may levy peer requirements.

Since the IRD was written before most of the above documents came into being, the IRD presently contains some requirements that properly belong in some of these other documents. At the present time, those requirements are only in this document, and therefore this document must be used as a companion document. As other requirements documents are established and mature, those requirements can be expected to migrate from this document to those documents where they properly belong.

2 Applicable Documents

Requirements in this Specification are traceable to the following documents:

GLAST Science Requirements Document Draft, May, 1999

GLAST Mission System Specification Draft, May, 1999

GLAST Spacecraft Performance Specification

GLAST Mission Concept Review Presentation Package, September 28, 1998

Delta II Payload Planners Guide <http://www.boeing.com/defense-space/space/delta/delta2/guide/index.htm>

GEVS-SE Rev A General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components <http://arioch.gsfc.nasa.gov/302/gevs-se/toc.htm>

CCSDS 102.0-B-4 Recommendation for Space Data Systems Standards. Packet Telemetry <http://www.ccsds.org/publications.html> - telemetry

CCSDS 202.0-B-2 Recommendation for Space Data Systems Standards. Telecommand, Part 2: Data Routing Service <http://www.ccsds.org/publications.html> - telecommand

CCSDS 701.0-B-2, "Recommendation for Space Data Systems Standards. Advanced Orbiting Systems, Networks, and Data Links: Architectural Specification." CCSDS Recommendation, Blue Book.

CCSDS 101.0-B-3, "Recommendation for Space Data Systems Standards. Telemetry Channel Coding." CCSDS Recommendation, Blue Book

CCSDS 201.0-B-2, "Recommendation for Space Data Systems Standards. Telecommand, Part 1: Channel Service." CCSDS Recommendation, Blue Book.

CCSDS 202.1-B-1, "Recommendation for Space Data Systems Standards. Telecommand, Part 2.1: Command Operation Procedures." CCSDS Recommendation, Blue Book.

SAE AS1773, Fiber Optics Mechanization of a Digital Time Division

Command/Response Multiplex Data Bus, Society of Automotive Engineers, September, 1995

Mil-STD-1553B, Aircraft Internal Time Division Command/Response Multiplex Data Bus, 21 September, 1978

Mil-STD 461E, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

NASA HDBK 4001. Electrical Grounding Architecture for Unmanned Spacecraft, February 17, 1998

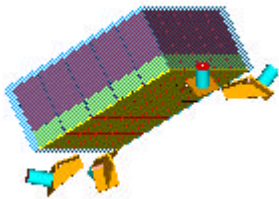
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3 Requirements

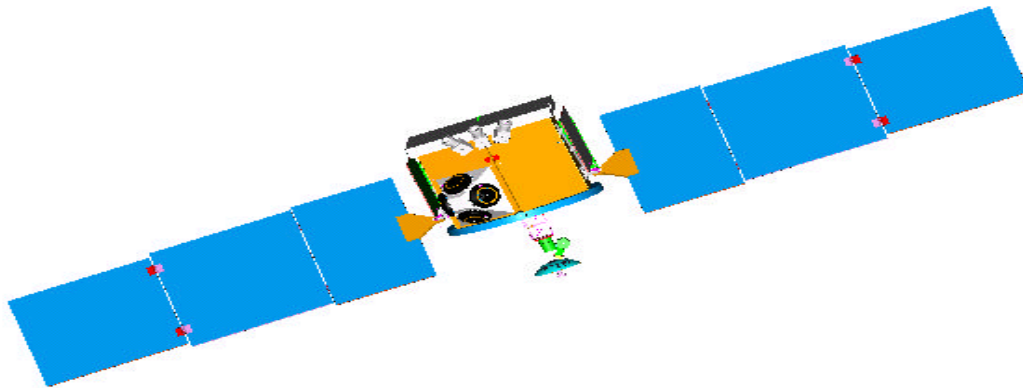
3.1 Definition of Flight System

3.1.1 System Modules

There are two major system modules in the GLAST flight system, a spacecraft module and a large area telescope module, as shown in Figure 3-1. These modules will be built separately, by different contractors. When integrated, these modules form the GLAST observatory. The large area telescope module is referred to as the primary science instrument in this document. Also shown in this figure, is the coordinate system for the observatory.



GLAST Spacecraft Module



Large Area Telescope Module

Figure 3-1. Flight System Modules

3.1.2 Flight System Interfaces

The flight system is defined as “everything that flies”, instruments, spacecraft, and launch vehicle. Figure 3-2 shows these components of the flight system and the interfaces between them. It also shows that the flight system has in-flight interfaces with the TDRSS communications satellite system, with direct ground stations, and with the constellation of GPS satellites.

Arrows are used in the figure to indicate generally an accommodation requirement. The spacecraft must directly accommodate the launch vibration environment, fairing envelope, and mounting configuration of the payload attach fitting. While on the launch pad, it receives umbilical power and communicates through the umbilical for command and telemetry.

The instruments also have direct interfaces with the launch vehicle in that they must accommodate the radiatively coupled launch environment (acoustics, pressure, and temperature) and the fairing envelope. Otherwise, the spacecraft must accommodate the instruments’ mechanical mounting and field of view requirements, as well as their thermal interface requirements. Additionally, the spacecraft provides power services and command and telemetry services to the instruments. It is these direct interfaces that are addressed in this document

The interfaces between primary and secondary instruments are TBD as are the interfaces between secondary instrument and spacecraft.

The spacecraft interfaces with direct ground stations for the downlink of high rate telemetry data. It interfaces with TDRSS when communications are needed at unscheduled times or when coverage is needed over a greater portion of the orbit than the direct downlink provides. The demand access service of TDRSS is used for unscheduled alert transmissions, both safe mode and transient events, and for unscheduled target-of-opportunity commanding. Extended coverage is needed during launch and early orbit operations, during any safe mode contingency operations, and for servicing the primary instrument (diagnostics, software uploads).

Finally, the spacecraft receives time and position services continuously throughout the mission from the GPS. The spacecraft distributes a pulse-per-second signal via hardware to provide an accurate time mark.

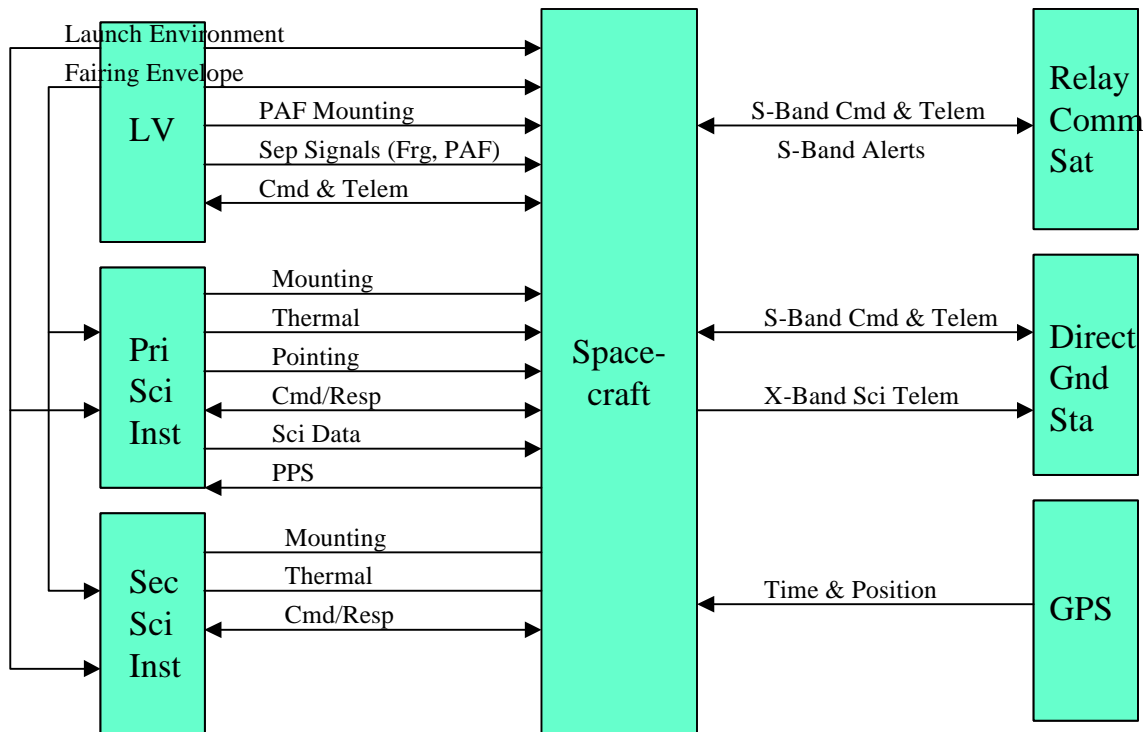


Figure 3-2. Flight System Interfaces

3.2 Interface Requirements and Constraints

3.2.1 General Interface Requirements

3.2.1.1 Axes Definitions

The SI and SC shall use a common definition of right-handed orthogonal axes as shown previously in Figure 3-1. The Z-axis passes through the geometric center of SI and SC. This axis is defined as the boresite axis of the observatory. The Y-axis is perpendicular to the Z-axis and is aligned with the axis of solar array rotation. The X-axis is orthogonal to the Y and Z-axes.

3.2.1.2 Celestial Coordinates

The observatory shall use celestial coordinates relative to the J2000 coordinate frame. Pointing commands to the observatory and pointing directions reported by the observatory shall be by Right Ascension (RA) and Declination (Dec) in J2000 coordinates.

3.2.1.3 Pointing Accuracy and Knowledge

The observatory shall be capable of pointing in any direction at any time, autonomously or by ground command, to an accuracy of <40 arcminutes [1σ diameter], as specified in the SRD.

The knowledge of the observatory pointing direction at any time, including during slew, shall be such that the total error is < 10 arcseconds [1σ diameter]. This error budget includes:

The intrinsic resolution of the star tracker system

The relative alignment of the star tracker system with the SI reference surface.

The relative alignment of the star tracker system and the SI reference surface shall be calibrated on orbit using celestial sources as part of the early operations checkout and on a periodic basis throughout the mission.

The stability of the relative alignment between the star tracker system and the SI reference surface, including all thermal-mechanical effects, shall be < 5 arcseconds [1σ diameter] throughout the mission.

3.2.1.4 Math Models

Mathematical models shall be readily exchanged electronically between the SI and SC contractors and the GSFC. This requires the use of common design tools and versions for file format compatibility. Alternate formats are acceptable only when approved by the Project Office. Exchange of mechanical design information shall use the IGES neutral file format (bounded surface models).

3.2.2 Mechanical

3.2.2.1 Fairing Envelope Constraint

The fairing envelope constraints shall be followed as shown in the reference document, Delta II Payload Planners Guide for the 3-meter fairing.

The maximum lateral, X-Y, dimensions of the SI shall be constrained to 1.8 m, as shown in mm in Figures 3-3, 3-4, and 3-5.. Note that the clearance between SI and fairing is reserved for solar arrays or other spacecraft components. The maximum Z dimension of the SI shall be constrained to 3.15 m. The Z dimension is based on an overall maximum height of 4.55 m for the observatory in the 3-m fairing of the Delta II, and an allocation of 1.4 m for the SC.

Figure 3-3. Fairing Diameter Constraint (all dimensions in millimeters)

3.2.2.2 Envelop of Primary SI

Figures 3-4, 3-5, and 3-6 show the stay-clear dimensions of the SI, around which the SC and the instrument interface structure must fit. Note that these figures show regions for access to the instrument for electrical integration and test with the spacecraft. These access regions shall not be occluded by any permanent SC structures. SI-provided, removable thermal and micrometeorite shields will cover this region after all testing is complete.

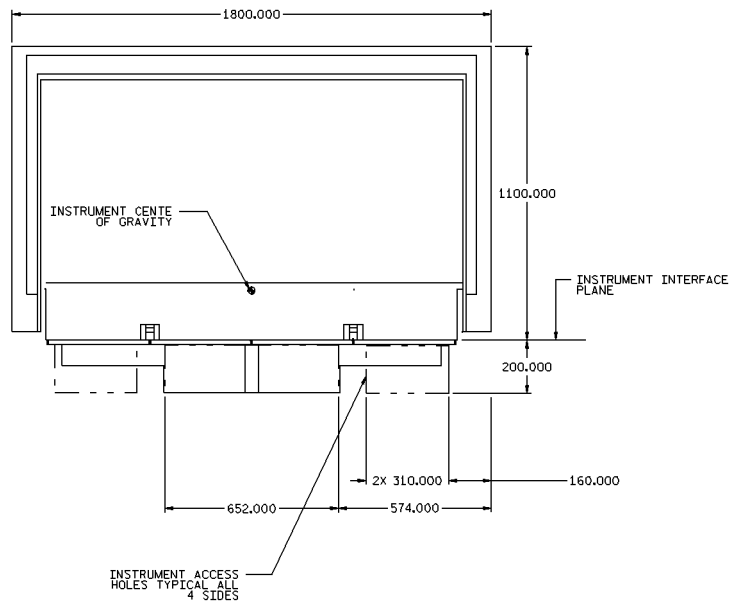


Figure 3-3. Side View of Primary SI (dimensions in mm)

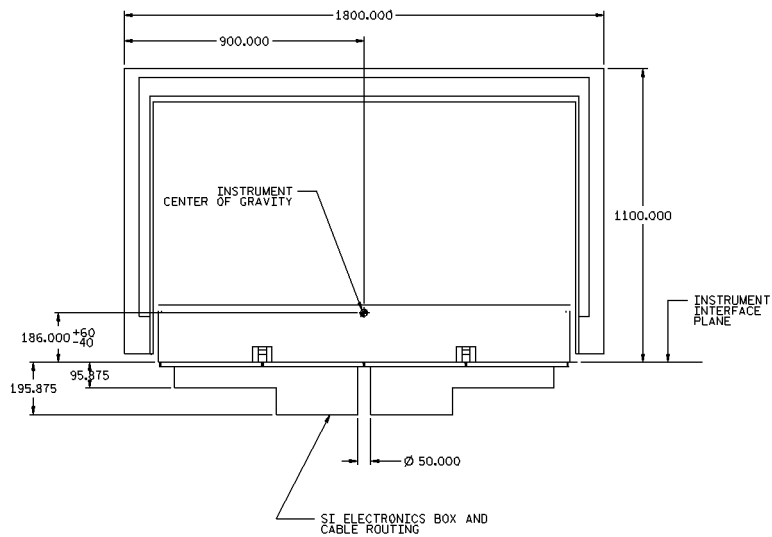


Figure 3-4. Elevation View of Primary SI (dimensions in mm)

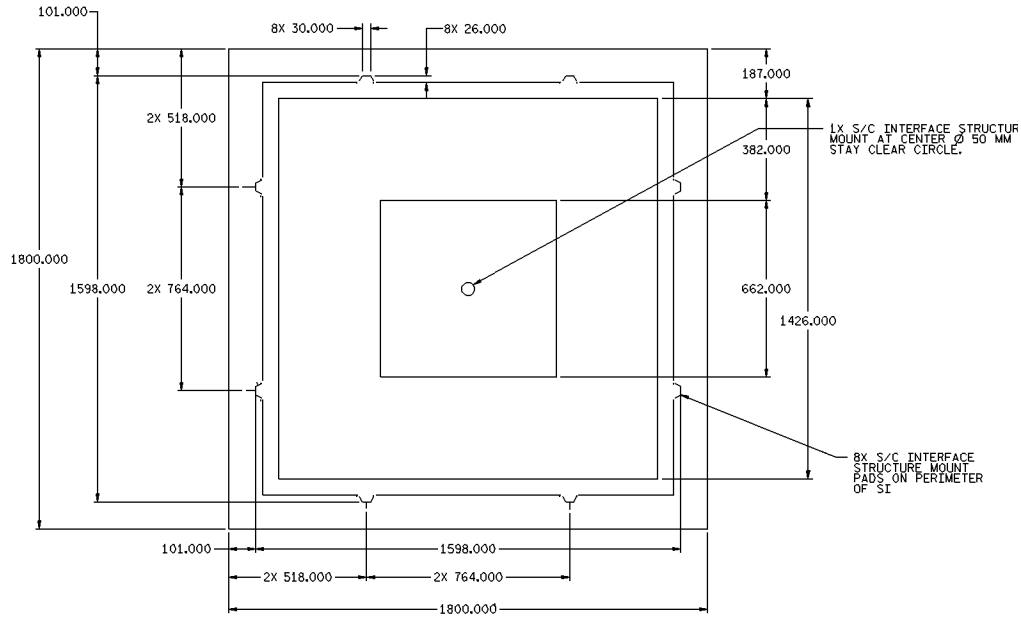


Figure 3-5. **Bottom View of Primary SI (dimensions in mm)**

3.2.2.3 Instrument Interface Structure

An interface structure shall adapt the structural configuration of the SI to that of the SC and provide mounting support for the SI. Mounting locations for the SI are shown in Figures 3-3, 3-4, and 3-5. Note the stay clear requirement for the optional center mounting support in Figure 3-5. The interface structure shall accommodate the routing of electrical cables and dedicated thermal links between the SC and SI as well as provide access to such components for integration. The SC contractor will provide the instrument interface structure.

3.2.2.4 SI Mass Constraint

The maximum launch mass of the SI shall be constrained to 3000 kg. This is exclusive of the instrument interface structure and star trackers, but inclusive of any SI hardware mounted on the SC bus, such as thermal radiators and electronics boxes.

3.2.2.5 CG Constraints

The observatory shall meet the payload requirements of the Delta II 7920-10 launch vehicle with the 6915 PAF and 3-meter fairing. The center of gravity (CG) requirements shall be adhered to as described in the Delta II Payload Planners Guide.

Note the instrument interface plane as shown in Figures 3-4 and 3-5 is the plane of attachment of the Interface Structure, but does not constitute the mass boundary of the SI.

The Z-axis location of the center of gravity of the primary instrument as shown in Figures 3-4 and 3-5 shall not exceed 0.246 m from its interface plane.

The spacecraft shall accommodate the center of gravity locations of the science instruments while meeting the observatory constraint.

3.2.2.6 Clear Field of View

In the deployed configuration on orbit, the SI shall have a minimum clear field of view of 2π sr (TBR) centered on the Z-axis above the instrument mounting plane. The spacecraft shall not introduce any fixed material above this plane, such as solar array restraint mechanisms. The rotation envelope of the solar arrays shall be kept below the instrument-mounting plane.

3.2.2.7 Alignment

The relative alignment of the star tracker system and the SI reference surface shall be surveyed on the ground and maintained to < 30 (TBR) arcminutes [1σ diameter] during environmental testing and launch to orbit.

3.2.2.8 Structural Design Requirements

3.2.2.8.1 Stiffness

3.2.2.8.1.1 Observatory

The fixed base stiffness of the SI-SC system shall produce a first mode frequency greater than 35 Hz, axial, and greater than 12 Hz, lateral.

3.2.2.8.1.2 SI

The fixed base stiffness of the SI shall produce a first mode frequency greater than 50 Hz.

3.2.2.8.1.3 SC

The fixed base stiffness of the SC shall produce a first mode frequency greater than 50 Hz.

3.2.2.8.2 Static Load Design

The design of SI primary structure shall use the quasi-static limit load factors in Table 3-1 applied at the center of gravity of the SI. Loads are given in units of gravitational acceleration, $g = 9.81 \text{ m/s}^2$.

Table 3-1. **Design Limit Loads**

Event	Liftoff/Transonic	MECO
Axis		
Thrust	+3.25/-0.8	+6.0 \pm 0.6
Lateral	\pm 4.0	\pm 0.1

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Thrust and lateral loads shall be applied simultaneously in all combinations. In the thrust axis “+” indicates compression and “-” indicates tension.

The design of secondary instrument structure and components shall use a limit load factor of ± 12.0 g applied to each axis independently.

SI primary structures include the SI support Grid, ACD, radiators, and Thermal/Micrometeorite Shield. Secondary structures include subsystem structures and components.

3.2.2.8.3 Factors of Safety

Factors of safety are multiplicative factors that are applied to limit loads to evaluate the yield and ultimate strength levels of the structural design. Guidelines for the appropriate use of factors of safety are given in the referenced GEVS-SE Rev A document.

3.2.2.8.4 Component Evaluation Random Vibration

The evaluation of components shall use the generalized random vibration power spectral density in GEVS-SE.

3.2.2.8.5 Acoustics

The acoustic spectrum is given in GEVS-SE for the Delta II launch vehicle.

3.2.2.8.6 Pyroshock

The pyroshock spectrum is given in GEVS-SE for the Delta II launch vehicle.

3.2.2.8.7 Finite Element Model

A finite element model of the SI and of the SC shall be delivered electronically by Jan 31, 2001 (TBR), to the GLAST Project Office at GSFC. These models are required in order to perform a preliminary coupled loads analysis. Results of the analysis shall be made available by Apr 30, 2001 (TBR), for use in planning for the PDR.

3.2.3 Thermal

3.2.3.1 *SI Thermal Design*

The design and performance of the SI thermal system shall be the responsibility of the SI contractor. The SI thermal system is defined to include all SI surfaces and thermal links that effect the SI heat balance. The SI thermal system includes all dedicated SI radiating surfaces that may be located on the SC module as well as all thermal interfaces and links that transport heat from these surfaces to the SI. The radiators shall be sized to allow for heat backloading from the solar arrays, Earth IR, and UV albedo energy.

The SI and SC modules shall be thermally isolated. A maximum of +5 watts (TBR) heat flow shall be permitted to conductively flow from the SC to the SI through the interface support structure and all cabling at the worst-case operational temperature range limits of the SI and SC.

The SC module shall provide the thermal isolation hardware. Preliminary thermal design shall use the environmental parameters of Table. 3-2.

Table 3-2 **Thermal Design Parameters**

Thermal Flux Source	Hot Case	Cold Case
Solar Constant	1419 W/m ²	1286 W/m ²
Albedo Factor	0.40	0.25
Earth IR	265 W/m ²	208 W/m ²

3.2.3.2 SI Radiator Accommodations

The SC shall accommodate thermal radiators for the SI.

3.2.3.2.1 Size and Configuration

The total radiating surface area shall be 5.4 m² (TBR). This area may be configured as 2 or more separate radiators.

3.2.3.2.2 Location

Radiating surfaces shall be parallel to the sides of the SI.

The radiators shall be mounted on the spacecraft bus.

The SI radiators will be located in the X-Z planes (normal to the Y-axes) of the observatory. A third radiator may be placed in the Y-Z plane on the -X axis if necessary. (Note that the observatory will maintain the sun line in the X-Z plane on the +X-axis in the normal operating modes, sky survey mode and pointed observation mode.)

3.2.3.2.3 Mounting

The SC shall provide mounting brackets and mounting thermal isolation as required for the SI radiators and their thermal links. Mounts shall be designed to permit less than 1 watt heat flow to the instrument radiator assuming that the spacecraft temperature is maximum and the instrument radiator temperature is -40 degrees C.. Mount point locations on the radiators are TBD. Field of View

The SC shall provide the SI radiators with a clear field of view of 2π sr (TBR), except for solar arrays, centered on each radiator normal.

3.2.3.3 Thermal Verification Requirements

Thermal/vacuum test environments for SI and SC verification testing, as well as SI/SC combined verification tests shall be according to GEVS-SE Rev A.

3.2.4 Electrical

3.2.4.1 Bus Voltage

The bus voltage supplied to the SI shall be $28\text{ V} \pm 6\text{ V}$ as seen at the input terminals of the SI.

The SI shall perform when subjected to voltage transients per CS116 requirements specified in TBD.

Under abnormal conditions the SI shall survive, without permanent degradation, steady-state voltages in the range: $0 < V < 38$ (TBR) VDC.

3.2.4.2 Bus Current

3.2.4.2.1 Overcurrent Protection

The spacecraft shall provide protection of the spacecraft power system by providing overcurrent protection devices on each SI power connection. The sizes and characteristics of the overcurrent protection devices shall be TBD.

3.2.4.2.2 SI Current Transients

The following SI requirements shall be measured when supplied by a voltage source having the impedance characteristics of the spacecraft power source:

SI current peaks associated with both turn-on inrush current and non-repetitive operational current transients shall not exceed TBD

During normal operations the SI shall limit current transient rate of change to TBD.

The SI shall limit turn-on inrush current transient rate of change to TBD.

The SI shall limit turn-off current transient rate of change to TBD.

3.2.4.3 Impedances

3.2.4.3.1 Power Source Impedance

The PSE output impedance shall be less than 70 milli-ohms to 3kHz (TBR).

3.2.4.3.2 SI Power Input Impedance

The SI power input filter shall present a symmetrical common mode and differential mode impedance to the power bus, as represented by the AC impedance of the differential mode and common mode input filters.

3.2.4.3.3 SI Common Mode Impedance

TBD

3.2.4.3.4 SI Differential Mode Impedance

TBD

3.2.4.4 *Power Constraints*

3.2.4.4.1 Peak Power

The peak power of the SI shall not exceed 1000 W (TBR).

3.2.4.4.2 Peak Power Duration

The maximum duration for the peak power dissipation of the SI shall not exceed 10 minutes (TBR) for each orbit.

3.2.4.4.3 Average Power

The average power dissipation of the SI shall not exceed 650 W per orbit.

3.2.4.5 *Primary Power Distribution*

The SC shall provide one prime and one redundant switched service to the SI. These services are mutually exclusive in that only one is active at a time. However, the design of the SI shall preclude damage to the SI if both services are active at the same time. The design of the SI shall also preclude damage to the SI if power is removed instantaneously without warning.

3.2.4.6 *Survival Heater Power Bus*

The SC shall provide a separate, redundant Survival Heater Power Bus to the SI. Survival power is used only for heaters and associated passive control circuitry that maintain the SI at a minimum turn-on temperature.

Each side of the Survival Heater Power Buses shall be continuously powered during flight.

Survival heaters shall be redundant. Survival heaters shall be electrically isolated from each other and from chassis. Survival heaters shall have independent power returns.

3.2.4.7 *Isolation*

The SI shall provide secondary power converters that isolate secondary from primary power returns. Secondary returns shall be isolated from primary returns by $> 1 \text{ M}\Omega$ (TBR) at dc.

3.2.4.8 *Grounding*

The observatory shall employ a “hard-grounded” primary ground system with multiple connections in the secondary systems. Figure 3-8 shows the configuration of the ground system. Observatory structure or an electrically conductive ground plane, known as chassis ground, shall provide the ground reference. The primary power system shall be connected to chassis ground at a single point at dc by $< 10 \text{ m}\Omega$ resistance(s) and at ac by an impedance of TBD $\text{k}\Omega$. Secondary loads shall each be referenced to chassis ground by a single connection. The chassis ground system shall not be used to conduct load current. The maximum ungrounded surface area, e.g., for MLI, shall be $< 10 \text{ cm}^2$ (TBR).

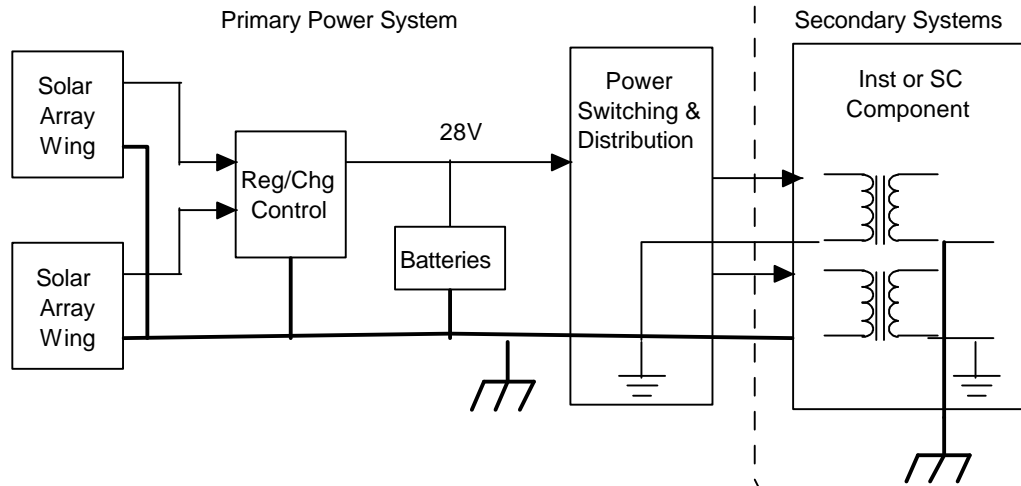


Figure 3-8. **Single Reference Ground System with Multiple Connections**

3.2.4.9 **EMC**

The SC shall be consistent with the Electromagnetic Compatibility (EMC) guidelines defined in the General Environmental Verification Specification for STS and ELV Payloads, Subsystems, and Components (GEVS-SE) and the Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment (MIL-STD-461E). Detailed requirements shall be documented in the GLAST EMC Requirements (TBD) document.

3.2.4.10 **C&DH Interfaces**

This section describes the physical interface requirements for the C&DH services, which include the science data, command and telemetry, time mark and frequency and any discrete interfaces.

3.2.4.10.1 Interface Conductors

Signal conductors shall use paired conductors. Paired conductors may include twisted pair, coaxial, twin axial, and dual coaxial types.

SAE AS1773 and IEEE 1393 fiber optic interfaces shall use multi-mode, 100/140micrometer, fiber optic cable with TBD connectors.

3.2.4.10.2 Interface Circuitry Isolation

TBD

3.2.4.10.3 Physical Characteristics of Interface Signals

TBD

3.2.4.11 *Test Point Interfaces*

The SC or SIs may elect to use test points to provide external access to internal circuitry via GSE. Use of test points shall meet the following requirements.

3.2.4.11.1 Spacecraft Integration and Test Use

Test points shall not be used during spacecraft integration and test, except as expressly approved and documented in formal procedures.

3.2.4.11.2 Performance Verification Limit

Data collected to verify acceptance or qualification of performance requirements shall be acquired through flight interfaces and not through test point interfaces.

3.2.4.11.3 Keyed Connectors

All test points shall be brought out to a separated, keyed connector(s), which shall be easily accessible.

Separate test connectors shall be used to segregate classes of signals.

When not in use and prior to launch, the connectors shall be protected with flight qualified covers.

3.2.4.11.4 Power and Load Isolation

The observatory shall not be powered through, nor significantly loaded, by test point interface circuitry, including connection to external GSE.

3.2.4.11.5 Failure Propagation

Test point interface circuitry shall not propagate failures to flight circuitry. This includes credible failures in GSE connected externally to the test point interface connectors.

3.2.4.11.6 Short-Circuit Isolation

Test point short-circuit isolation shall also be provided. The observatory shall operate within specification in the event any test point is shorted to the power bus, ground, or another test point, and upon removal of the short.

3.2.4.11.7 Grounding Integrity

Test point interface circuitry shall not compromise grounding requirements, either by design or use.

3.2.4.11.8 Flight Standards

Test points shall be designed and implemented in accordance with all applicable flight standards and component ratings.

3.2.4.11.9 Test Point Documentation

Test point interfaces, functions and GSE interconnection shall be documented in TBD.

3.2.5 SI and C&DH Data Services

3.2.5.1 Command, Telemetry, and Data Bus

Commands, telemetry, time message, and ancillary data shall be transferred between the SI and the C&DH via a serial command, telemetry, and data (CTDB) bus as defined by SAE AS-1773.

3.2.5.1.1 CTDB Protocol

CTDB data shall utilize the communications protocol at the physical layer as defined by SAE AS-1773..

3.2.5.1.1.1 Command Data

Commands transferred over the CTDB shall be formatted per CCSDS 203.0-B-1 (Telecommand Data Management Service Blue Book).

3.2.5.1.1.2 Telemetry Packets

Telemetry packets transferred over the CTDB shall be formatted per CCSDS 102.0-B-4 (Packet Telemetry Blue Book).

3.2.5.2 SI Housekeeping Data

The SI shall provide the C&DH, upon request, a housekeeping data set as defined in the LAT Unique Instrument Interface Document (TBR).

3.2.5.3 Pulse per Second Bus

The C&DH shall provide the SI a pulse-per-second (PPS) signal accurate to $\pm 0.5 \mu\text{sec}$ (TBR) referenced to the on-board GPS receiver.

3.2.5.4 Time Distribution to SI

The SC C&DH shall issue a time message that gives Universal Coordinated Time (UTC) (TBR).

3.2.5.5 GPS Receiver Time Dropout

The PPS signal shall be provided, without interruption, to the SI in the event of a loss of the time signal provided by the GPS receiver.

3.2.5.6 PPS Signal Drift

The PPS signal shall drift no more than $\pm 1 \mu\text{sec}$. (TBR) when a GPS time signal loss occurs.

3.2.5.7 Time Message Distribution

The Time Mark Message shall be issued no more than 100 ms (TBR) after the transition of the PPS time mark signal.

3.2.5.8 Ancillary Data

The C&DH shall provide an ancillary data packet to the SI at the attitude control loop rate of 5 Hz (TBR).

The ancillary data packet shall contain the time-tagged attitude vector and the time-tagged orbit position vector based on GPS data processed by the ACS.

3.2.5.9 Analog Signals

The C&DH shall provide 128 primary and 128 redundant analog channels (TBR - the SI may provide these services internally) for monitoring SI health and safety. There are TBD analog thermistor signals to monitor temperature. The sampling rate for these signals shall be from 1 to 10 Hz.

3.2.5.10 Discrete Control Signals

The C&DH shall provide 16 primary and 16 redundant discrete pulse signals channels (TBR - the SI may provide these services internally) for configuration and power control of the SI.

3.2.5.11 Discrete Monitor Ports

The C&DH shall provide 16 primary and 16 redundant discrete monitor ports (TBR - the SI may provide these services internally) for monitoring configuration status of the SI.

3.2.5.12 SI Command Storage

The C&DH shall provide 256 kbytes (TBR) of stored command memory dedicated only to SI utilization.

3.2.5.13 SI Command Frequency

The C&DH shall transmit commands to the SI at a maximum rate of 2 (TBR) commands per second.

3.2.5.14 SI Configuration Commands

The SI shall be configured by commands issued by the C&DH.

3.2.5.15 SI Table Loads

The SI shall load internal tables from commands issued by the C&DH.

3.2.5.16 SI Memory Loads

The SI software shall be reprogrammable via software load commands.

3.2.5.16.1 Memory Load Rate

Memory loads shall be provided to the SI at 4 kbps for TDRSS contacts and 2 kbps for ground station contacts.

3.2.5.16.2 SI Memory Dumps

Commands shall allow dumps from SI program memory, data memory, or both.

3.2.5.17 *Real-Time Pointing Commands*

Execution status of ground-issued pointing commands shall be provided to the SI in the ancillary data packet.

Note: This capability will be used in early-orbit checkout and in contingency operations in which continuous communications are maintained with the observatory through TDRSS. It will also be used in normal operations via the TDRSS demand access service for coordinated observations with other observatories.

3.2.5.18 *Sky Survey Mode*

Status of SC sky survey mode autonomous pointing shall be provided to the SI in the ancillary data packet.

3.2.5.19 *Pointed Observation Mode*

Status of time-tagged stored pointed-observation mode commands shall be provided to the SI in the ancillary data packet.

3.2.5.20 *Transient Event Repointing*

The requirements in this subsection are based on the following system concept. Transient event repointings may interrupt the normal observation modes, viz., sky survey and pointed observations. These interruptions are under the control of an enable. They are inhibited if a telemetry contact is scheduled within the allowed duration of the repointing command. Secondary targets during earth occultation are not used during transient event repointings.

Currently, there are four possible sources of repointing commands, 1) target of opportunity commands via the Science Operations Center, 2) detection of high energy gamma-ray burst by the primary science instrument, 3) detection of low energy gamma-ray bursts by the secondary science instrument, and 4) detection of active galactic nuclei by the primary science instrument. The direction of repointing is determined by the source of the command. All command sources need to use the same coordinate reference frame. The duration of repointing is presently the same for all sources and is set by ground command. However, it could be different for each type of transient, and it could be set by the source of the command. Finally, a go-no go decision needs to be made based on current pointing direction, proposed repointing direction, time to slew, and viewing solid angle. Where this decision is made is currently TBD.

3.2.5.20.1 Repointing Control Enable

When enabled, the SC shall issue a repointing command to the ACS that supercedes the last SC-generated pointing command. The SC C&DH shall report status to the SI in the ancillary data packet.

3.2.5.20.2 Repointing Control Enable Window

The time duration of transient event repointings shall be controlled by a ground-issued command.

3.2.5.20.3 Transient Alerts to Ground

Upon receipt of a transient alert message from the SI, the SC C&DH shall send the message immediately to the ground.

3.2.5.20.4 Pointing Coordinates

Transient alert message shall contain the pointing direction coordinates per section 3.2.1.2.

3.2.5.20.5 Transient Event Pointing Commands

The C&DH shall issue a transient event repointing command, derived from the alert message, to the SC ACS that contains the direction and duration of the transient event.

3.2.6 Science Data Interface

3.2.6.1 *Science and Telemetry Data*

The SI shall output science and telemetry data, via a high-speed fiber optic serial interface (HSFSB). The HSFSB shall comply with the IEEE 1393 Spaceborne Fiber Optic Data Bus standard.

3.2.6.1.1 High-Speed Serial Interface Data Rates

The SI-SC data rate on the HSFSB shall be 150 Mbps or less.

3.2.6.1.2 Packet Format

All SI data transferred over the HSFSB shall be formatted per CCSDS 102.0-B-4 (Packet Telemetry Blue Book).

3.2.6.1.3 Packet Size

The SI shall utilize variable length CCSDS source packets up to a maximum length of 64 kbytes.

3.2.6.2 *RT to RT Communications*

When an RT-to-RT communications request is received, the C&DH shall send a receive command to the receiving RT and continuously send a transmit command to the sending RT.

3.2.7 Fault Protection

3.2.7.1 *Fault Tolerance*

SC and SI systems and interfaces shall be single-fault tolerant.

3.2.7.2 *Fault Detection and Correction*

The SI and SC shall have on-board fault detection isolation and recovery (FDIR) hardware and software.

3.2.7.3 *Safe Mode*

The SC shall enter safe mode when a mission critical fault is detected and cannot be corrected by on-board processes.

3.2.7.4 *Safe Mode Notification*

The C&DH shall send the SI a message indicating transfer into safe mode except when the mission critical fault is loss of the C&DH.

3.2.7.5 *Load Shedding*

SI power shall be disconnected when ground-based or on-board fault analysis determines load shedding is required.

3.2.7.6 *Load Shedding Notification*

The C&DH shall provide a message to the SI 15 seconds (TBR) prior to issuing a command to disconnect SI power.

3.3 *Space Environmental Estimates***3.3.1 *Charged Particle Radiation***

This section gives the total dose and single event upset (SEU) requirements for the charged particle radiation environment.

3.3.1.1 *Total Dose*

The total dose for a 5-year mission in the GLAST orbit, beginning in 2005, is given by the dose-depth curve in Figure 3-9.

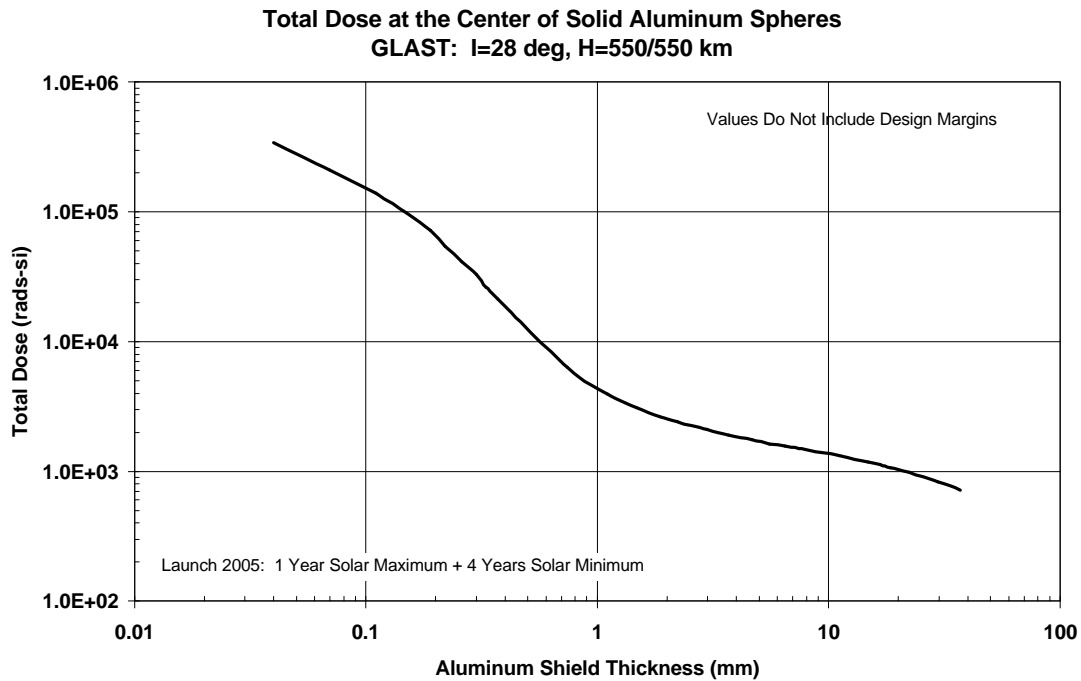


Figure 3-9. **Total Dose-Depth Curve.**

3.3.1.2 *Total Dose Design Margin*

A multiplicative factor of 2 shall be applied to the total dose estimate for estimate uncertainty, and an additional factor of 2.5 (TBR) shall be applied to achieve an overall design margin of 5. Shielding shall be designed and parts chosen to yield the required design margin.

3.3.1.3 *LET Spectrum*

The LET energy spectrum for direct ionization by heavy ions is given in Figure 3-10.

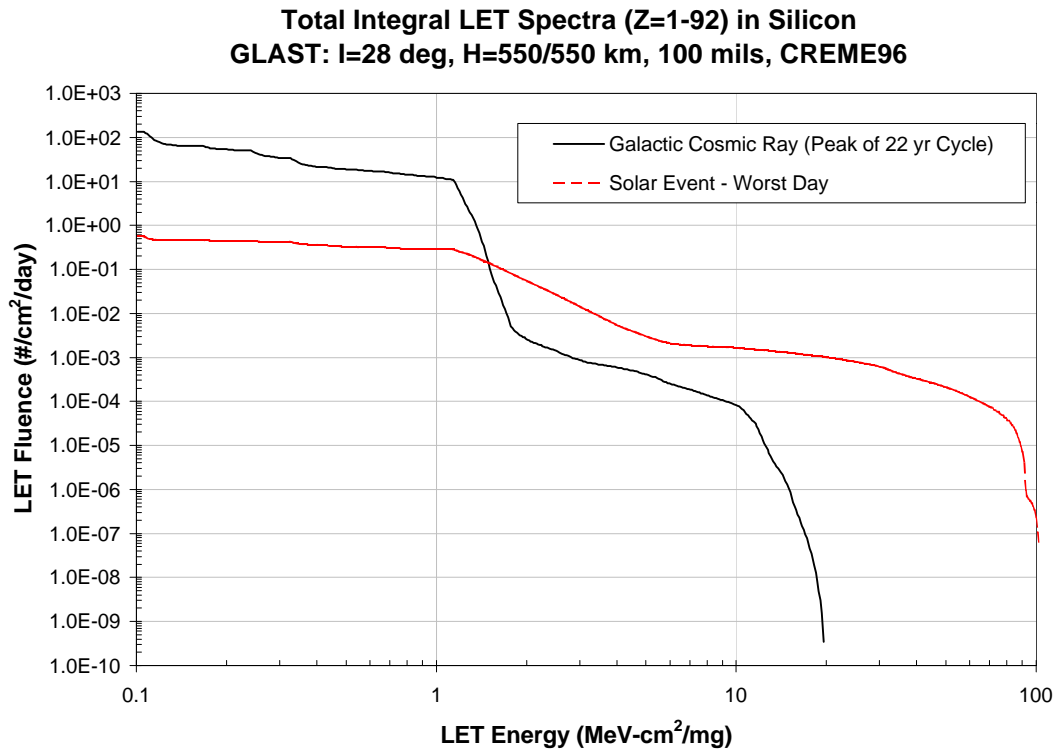


Figure 3-10. LET Spectra.

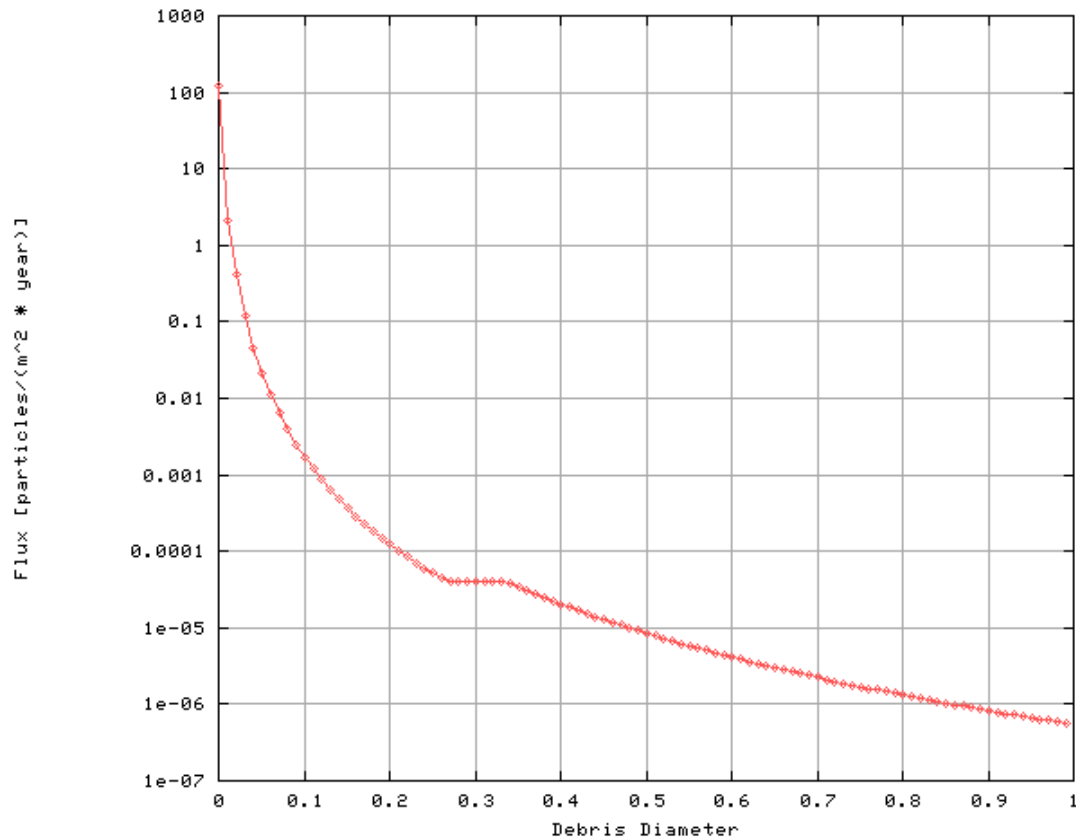
3.3.1.4 *Single Event Effects Immunity*

Electronic parts shall be selected for immunity to single event effects. All parts shall be selected for immunity to single event latch-up. A linear energy threshold of 8 MeV/mg/cm² (TBR) shall be used as a guideline to select parts for reasonably low probability to single event upset due to proton induced secondary.

3.3.2 Meteoroid and Debris Flux

3.3.2.1 *Meteoroid Flux*

Figure 3-11 gives the meteoroid flux at 550 km. The meteoroid environment encompasses only particles of natural origin. The average mass density for all meteoroids is 0.5 grams (g) per cubic centimeter, and the average velocity for all meteoroids is 20 kilometers per second. The meteoroid flux is from the NASA SSP-30425 (1991) model that can be found at <http://envnet.gsfc.nasa.gov>.



Debris Diameter is in cm.

Figure 3-11. Meteoroid Environment at 550 km.

3.3.2.2 Debris Flux

Figure 3-12 gives the debris flux at 550 km. The orbital debris environment is composed of residue from man-made satellites and launch vehicles. The average velocity for objects smaller than 1 centimeter is 10 km/sec, and the average mass density is 2.8 g/cm³. This flux is from the Orbital Debris Model, also found at <http://envnet.gsfc.nasa.gov>. It was run with the following parameters:

Debris Diameter (cm) varied,

Altitude 550 km,

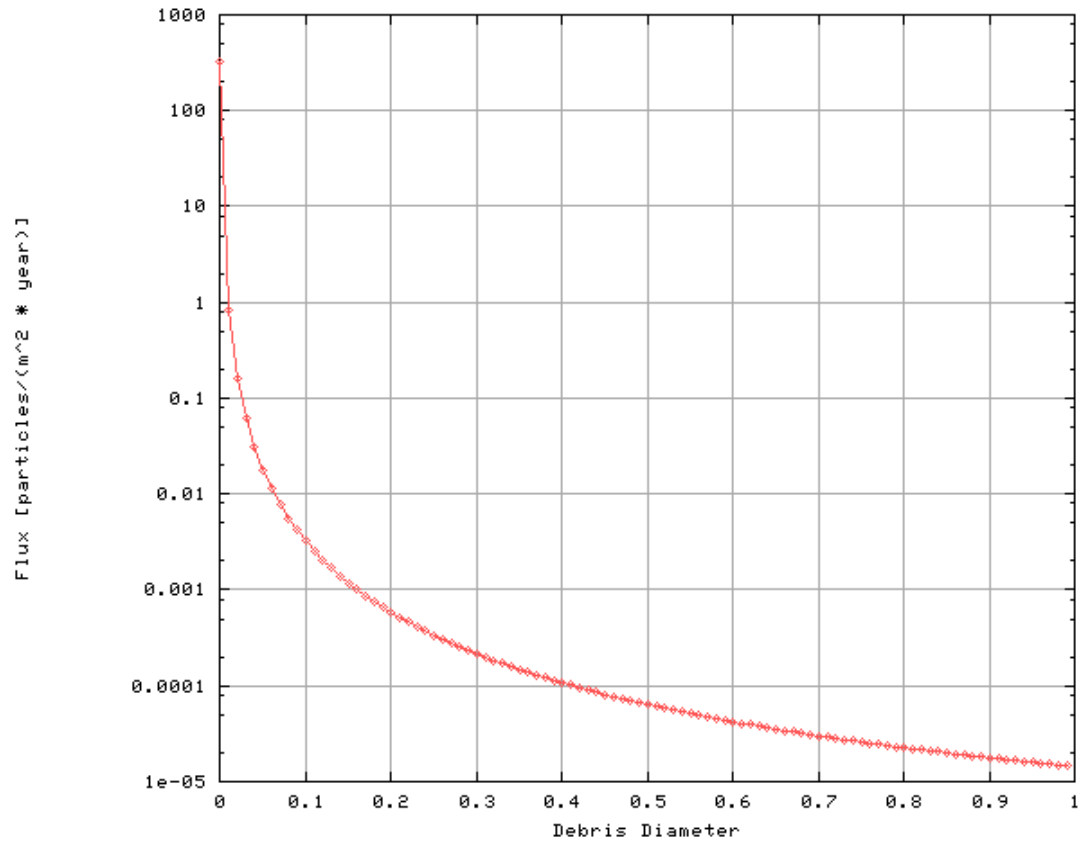
Inclination 28.5 degree,

Year 2005,

Traffic Growth Rate 5%,

Small Object Growth Rate 2%,

SolarFlux 147.13



Debris Diameter is in cm.

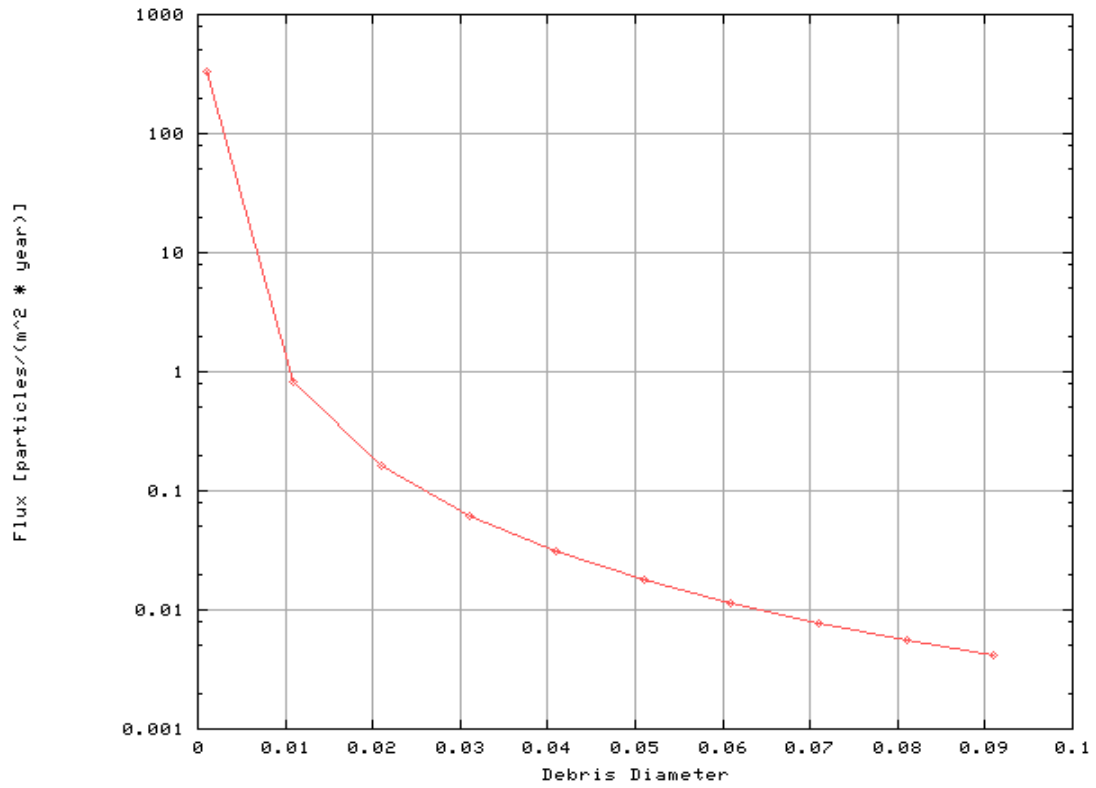


Figure 3-12. Debris Environment at 550 km.